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Atty Docket: 10559-398001/P10335

Remarks

Reconsideration of the above referenced application in view of the enclosed amendment and remarks is requested. Claims 1, 6-11, 16-21, 27-29 and 31 have been amended. Claims 4, 5, 14, 15, 24 and 25 have been canceled. Claims 35 and 36 have been added. Claims 1-3, 6-13, 16-23, and 26-36 are now pending. Claim 17 was previously presented to put it into independent form. However, intervening limitations were inadvertently omitted. Claim 17 us amended herein to recite the omitted limitations.

**ARGUMENT**

Applicant's method generally is comprised of smoothing an image using a sharply peaked filter, followed by low pass filtering using a high frequency cutoff filter, and optionally followed by median filtering in regions. In various embodiments, lowpass filtering and/or median filter are performed in areas where there are no edges. On the surface, the method taught by Wong seems similar. However, there are some very significant differences. Applicant's method requires a focus on the lowpass filter, while Wong teaches that a non-linear filtering step is the most important. More importantly, the method taught by Wong is iterative. At Col. 5, lines 10-12, Wong teaches that a pipeline for inverse halftoning includes *k* iterations, or stages. While Wong's method may result in a good image, Applicant recites a method providing a good image in one pass, i.e., no iterations, and therefore results in a more efficient method than taught by Wong. Applicant's method minimizes computation which may be important for many applications.

Further, Applicant's lowpass filter method differs from the filtering taught by Wong. There are a large number of different types of lowpass filters. If a lowpass filter is used that is too broad, the filter will average adjacent pixel values too much, resulting in edges being smoothed. On the other hand, filters like the hamming with a sharp cut off frequency may be used instead to avoid smoothing edges significantly.

Applicant recites a lowpass filter that is tailored to halftoning. Applicant does not just describe a filter with a sharp cutoff like a hamming filter or an averaging lowpass filter. Applicant's filter uses a combination of a sharply peaked filter (the center pixel in the filter window has much larger weight than those around it, see examples (a) and (b) on page 2 of the Specification) for smoothing and then a sharp cutoff filter like a hamming. It is not obvious to those skilled in the art that combining filters with these frequency characteristics works particularly well for the inverse halftoning data. Nor is this technique taught by the cited references.

Applicant uses both filters, in sequence, because neither filter will significantly smooth edges. Also, combining filters other than those recited by Applicant may require an iterative process as that taught by Wong. The sharply peaked filter is good at smoothing the speckled appearance of the halftoned image. However, the sharply peaked filter leaves the image with patches of similar, but not the same, color or gray level. Regions within a patch are smooth, but the patches have objectionable boundaries. The lowpass filter with a sharp cutoff does a good job of removing these objectionable boundaries without smoothing real edges whose boundaries have significantly greater color or gray level differences. However, the sharp cutoff filter does not do a good job of removing the speckled appearance. This particular combination is not shown or suggested by the cited references.

Applicant has made measurements that demonstrate the benefit of combining these particular filters. The metric used is called PSNR. It is the most common method for comparing images. While this metric is not a panacea, it is used because it is easy to compute and does a reasonably good job. Generally when two images have a high PSNR they look more similar than those with lower PSNR. The Applicant notes that a difference of about 2 is easily noticeable. Computation of PSNR basically involves subtracting pixel values of one image from another. In an example image, PSNR results are reported comparing the original image with the halftone image of 7.9, with the narrow filter smoothed halftone image of 20.4, with the sharp cutoff filter smoothed halftone image of 25.2, Applicant's combined filter smoothed halftone image of 30.7 and the combined filter followed by median filtering of 31.5. Typical inverse halftoning PSNR results reported in the literature are in the vicinity of 31. The combined filter gives results in the

range of much more complex (or iterative) methods while separate low pass filters alone do not. It is not taught or suggested by the cited references that simply combining these techniques in one pass will be so much more effective than used alone. Also, it is not taught that for situations requiring fast computation that a combination of these filters can produce results that are close to those of much more computationally intensive methods.

Regarding median filters, the filter taught by Wong is not a median filter as recited by Applicant. Typically, a median filter replaces the pixel in the middle of a 3x3 window (or less often 5x5) with the pixel with the median value in the window. This means that if the 9 values in the window are sorted, the pixel value is replaced with the value of the fifth out of nine largest value. This is the value in the middle of the range. The Examiner is incorrect that Applicant's method uses an average as taught by Wong's non-linear filter. Nor is Wong's filter a median filter. There is an important difference between using averaging and median filtering for removing noise. The result using averaging combines all pixel values in the window so the result is influenced by the noisy pixels. A median filter, by only using the middle value in the window, ignores the noisiest pixels in the window that are likely to have lower or higher values than the others.

The median filter improves the appearance, but the combined lowpass filter is also novel. While Wong teaches a method having lowpass filtering followed by a noise removing filter that may avoid edges, there are important differences in each step. Applicant's method uses a combination of lowpass filters that have frequency characteristics that are specifically designed to remove both the problem of speckles and patches. Applicant's noise removing filter ignores the noisiest pixels in a window, unlike the method taught by Wong, which by using averaging, gives results influenced by all pixels in a window. In the end, Wong's method may provide results comparable to Applicant's results, however, Wong teaches an inefficient and computationally intensive method not suitable for all applications.

Claims 1-3, 5-10, and 31-32 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent 5,506,699A to Wong (hereafter, "Wong"). This rejection is respectfully traversed and Claims 1-3, 5-10, and 31-32 are believed allowable as amended based on the foregoing and following discussion.

As discussed above, Wong teaches an iterative method and apparatus for converting a halftone image into a continuous tone image. Wong teaches a method using a low pass filter and statistical smoothing (Fig. 2). Claim 1, as amended, requires a using a combination of sharply peaked filter to smooth the image, then detects edges in the smoothed image and then performs lowpass filter using a high frequency cutoff filter on non-edge areas of the smoothed image. At Col. 6, lines 12-20, Wong discusses that the sample variant of the defined neighborhood of an edge tends to be larger than in the case in which the window does not contain an edge. Wong merely states an axiom of halftone images. Wong does not teach or suggest the step of *detecting* edges as recited in the claim. Further, Wong discloses that statistical smoothing results in a gray scale image without overly blurring the image at its edges. It is *implied* that the performance of statistical smoothing on a halftone image provides less blurred edges. At no time does Wong teach a device which detects an edge in a smoothed image. Further, Wong teaches an iterative process of a variety of lowpass filters. Col. 5, lines 18-19 states that the filters may vary along the pipeline and that the *k* filters need not be identical. Applicant's recite a process where a sharply peaked smoothing filter is followed by a high frequency cutoff filter in one pass. Applying various filters as taught by Wong will not result in the computationally efficient method as recited by Applicant.

The Examiner cites Col. 5, lines 13-18, and implies that Wong teaches a low pass filter (halfband filter) that acts only in regions that will be blurred by the smoothing operation. The Examiner implies that the halfband filter taught by Wong acts as an edge detector because it *results* in less blurring of the image at the edges. This line of reasoning is faulty for the same reasons as previously stated. It will be apparent to one of ordinary skill in the art that the act of *detecting an edge*, as recited in the Claims, is not at all equivalent to the performance of an act that as a *byproduct* provides less blurred edges. Moreover, at no time does Wong teach or suggest applying an edge filter to an already smoothed image, as specifically recited in Claim 6, 16, 26, 32 and 34.

Claims 4 and 14 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Wong in view of U.S. Patent 5,333,064 to Seidner et al. (hereafter, "Seidner et al."). Claims 1 and 11 now recite the limitations previously recited in Claims 4 and 14. This rejection is respectfully

traversed and Claims 1 and 11 are believed allowable as amended based on the foregoing and following discussion.

Seidner et al. teach an apparatus and method for descreening and for performing resolution changes on a half-tone image in order to produce a continuous tone image. The combination of the teachings of Wong and Seidner et al. do not provide all of the elements recited in Claims 1 and 11. Applying the teaching of Seidner et al. to Wong will not result in Applicant's computationally efficient invention. Wong teaches an iterative method. Substituting Wong's lowpass filter with a high frequency cutoff filter does not provide the recited combination. Further, there is no motivation to combine the two cited references, as neither reference indicates that combining a sharply peaked smoothing filter with a high frequency cutoff filter in a single pass will result in an image of the quality resulting from iterative method taught by Wong.

Claims 11-13, 15-23, 25-30, 33 and 34 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Wong in view of U.S. Patent 5,027,078A to Fan (hereafter, "Fan"). This rejection is respectfully traversed and Claims 11-13, 15-23, 25-30, 33 and 34 are believed allowable as amended based on the foregoing and following discussion.

The Examiner asserts that Fan teaches an algorithm using a memory to store executable instructions. Combining Fan with Wong will not result in Applicant's claimed invention. Fan teaches a method of unscreening a digitally created halftone image to reconstruct a continuous tone image, including the determination of the parameters of the halftone screen used to generate the halftone image. Fan teaches applying a filter (18) before an optional smoothing operation (22) in Fig. 1. Fan does not teach applying a filter to a smoothed image. Thus, there is no motivation to combine the teachings of Fan with Wong. Regardless of whether there is motivation to combine the teachings of Fan to the teachings of Wong, the two references combined do not show or suggest the combination of elements recited in Applicant's claimed invention, as discussed above.

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## CONCLUSION

In view of the foregoing, Claims 1-3, 6-13, 16-23, and 26-36 are all in condition for allowance. If the Examiner has any questions, the Examiner is invited to contact the undersigned at (703) 633-6845. Early issuance of Notice of Allowance is respectfully requested. Please charge any shortage of fees in connection with the filing of this paper, including extension of time fees, to Deposit Account 50-0221 and please credit any excess fees to such account.

Respectfully submitted,

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